Aviation Research

ou Decide

Electroactive Polymers 1: Piezoelectric Materials

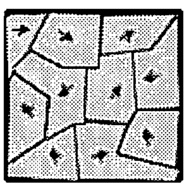
iezoelectric Materials require an input of voltage to change shape. In the 1880s, piezoelectricity was discovered hrough experiments with quartz done by Jacques and Pierre Curie.

ow it works:

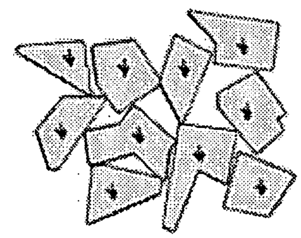
Piezoelectric materials have two crystalline configurations. One structure is organized, while the other is not. rganization of the structure has to do with polarization of the molecules that make up the material. Hence, a non-olarized material has a non-organized structure, while the polarized material is organized. To polarize the material, oltage or electricity must be conducted through it. As a result of this electrical force, the molecules of the material eorient themselves, thus changing the shape of the material; this is called electrostriction.

he picture below shows this process at a microscopic level. Change in shape can produce mechanical force, as well as hanges in physical characteristics (like density, shown below).

Non-polarized material:



Polarized material:



On the right, shape change is produced with input of electricity.

On the left, electricity is produced with input of shape change.

imilarly, if mechanical force is exerted on the material to change its shape, an electrical field is produced; this is called iezoelectric effect. Electrostriction and piezoelectric effect are opposite phenomena. In the graphic below, a thin iezoelectric material within a plastic sheath is being bent, and electricity is being generated and passed through the red ires at the end.

PZT is the most popular piezoelectic material in use. Its physical properties can be optimized for certain applications by controlling the chemistry and processing of this material. Therefore, it can have a variety of compositions, geometries, and applications. Limitations in its use are related to high excitation voltages needed, mechanical durability, and stability in coupling the material to the control system and/or structure.

Some piezoelectric materials are:

- quartz
- barium titanate
- cadmium sulfide
- lead zirconium titanate (PZT)
- piezoelectric polymers (PVDF, PVC)

xamples of Applications and Links:

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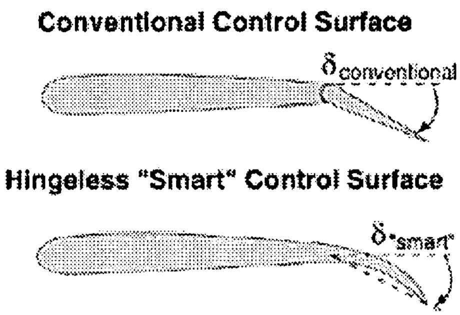
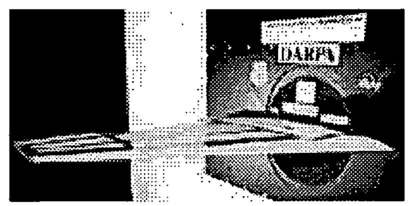
ite, but to provide a convenient link to relevant sites which are managed by other organizations, companies, or ndividuals.

- Smart Antenna. Antenna for space station communication. Shape of antennae changes so can send varying electromagnetic signals specific to the country receiving it. A similar antenna could be used to replace multiple antennas used on airplanes or at airports. The antenna is quickly and easily tunable to different frequencies.
- Swimming Vehicle using piezoelectric actuator. See this page for more information and a QuickTime movie: http://rclsgi.eng.ohio-state.edu/~gnwashin/parts/swim.html
- New aircraft called "smart wing aircraft." Traditionally, leading and trailing edges of wing move with hydraulic actuators. However, this is bulky with many mechanical parts, and hydraulics can leak. Smart Wing Aircraft uses electromagnetic actuators so that the wing is a continuous form and is flexible. This improves structural integrity of the control surface, while maintaining its multi-functionality. More information can be found at: http://www.aero-space.nasa.gov/curevent/news/vol2_iss6/bird.htm (where two graphics below are from) and http://www.nas.nasa.gov/Main/Features/2000/Winter/smartwing2_2.html





- Smart bifocal eyeglasses (~2 cm x 1cm actuator) that can change focus with subtle facial movement.
- Smart shoe stores energy created through walking. Adapters built into shoe can transfer that energy to charge cell phone, etc. May help soldiers who typically have to bring 60 pounds of batteries into battle! See short paper by Thad Starner: http://testarne.www.media.mit.edu/people/testarne/TR328/node8.html
- General Motor's StabiliTRAK: Yaw Rate Sensors for Chassis Control in General Motors Cadillacs, used for testing cars to measuring yaw and prevent rolling accidents. Uses micro-machined double-ended quartz tuning forks that measure yaw using the Coriolis effect.
- Piezoceramic motors used to cancel out through counteraction vibrations/sound in automobiles and airplanes.
- Smart sensors for side impact diagnostics in automobiles. Used for deploying air bag at different levels, in real time.
- Sensors: wiper activation sensors in automobiles; active flow control sensors for monitoring airframe health in airplanes.
- Sonar arrays for collision avoidance in automobiles.

You Decide Intro
You Decide Scenario
You Decide Decision Making Process